

Challenges and Lessons Learned from the Development of Standard Protocols for the Evaluation of Ballast Water Treatment Systems

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California State Lands Commission
Prevention First Conference
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United States
Coast Guard



Developing Test Procedures

(One Person's In-Progress Perspective)

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Lessons Learned

- Run like h...
- Make useful friends
- Trust but verify
- Don't bust your @\$@ if you can burn some gas
- Don't color outside the lines
- Ignore the chatter (politicians and press)
- Its not a horse race
- More \$\$ = More lawyers
- Murphy!

Outline

- U.S. Coast Guard authority
- Higher level requirements
- Key partnerships
- Integrated procedures
- Validation
- Harmonization

USCG interest in testing BW treatment systems

- USCG authorized by Congress to approve BWM methods
 - NANPCA 90/NISA 96
 - Sec 1101 (b)(2)(B)(iii) and (c)(2)(D)(iii)
 - “...if the Secretary determines that such alternative methods are at least as effective as ballast water exchange...”
- Need to develop procedures by which to assess efficacy

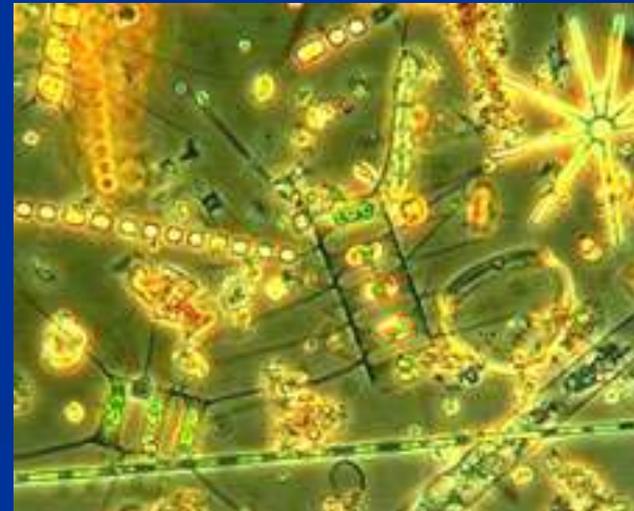
USCG Approval of Equipment

- 46 CFR 159 (Subchapter Q)
 - Approval of Equipment and Materials
 - Application requirements
 - Application review procedures
 - Test Requirements
 - Efficacy
 - Design, materials and construction appropriate for shipboard
 - Environmental tests
 - Vibration
 - Heat & Humidity
 - Incline
 - Other, as appropriate for equipment and use
 - Independent laboratories
 - Recognition by USCG
 - Qualifications

Ballast Water Treatment

General Requirements

- **Effective for full range of organisms including**
 - **Bacteria (0.2 -2 um)**
 - **Large Plankton (200 um - 20 mm)**
 - **All life stages**
 - **Sexual and asexual**
 - **Aerobic and anaerobic**
- **Effective under wide range of conditions**
 - **Salinity**
 - **Turbidity**
 - **Organic content (Particulate and dissolved)**



Approving BWM Systems

- **Type Approval of systems**
 - Rigorous land-based tests
 - Shipboard performance assessments
- **Requires standard test protocols and methods**
 - validated methods and apparatuses
 - controlled and repeatable conditions.
- **Results need to be**
 - **Comparable between tests**
 - different treatment equipment at same location
 - different test facilities
 - **Scientifically rigorous**
 - **Legally defensible**

That's it for "Approval"

(in this talk)

- Requirements for approval of ballast water management systems will be part of published regulations.
 - APA: No ex parte communication prior to publication
- Comments today will focus on generic assessment of efficacy / performance
 - Ideally, stakeholders would be interested in high quality credible data on performance

How Effective?

- Back in the day...
 - Numerous independent efforts to develop BWMS
 - Wide range of testing approaches and metrics
 - USCG R&D Center 2002 evaluation:
 - Testing efforts inadequate
 - Design
 - Methods
 - Documentation
- Independent of “approval” – need to identify appropriate procedures
 - Understand state of technology
 - Identify areas for improvement

Partnerships

EPA Environmental Technology Verification Program



United States
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Battelle

Coastal Resource and
Environmental Management

NRL Center for Corrosion
Science and Engineering



Lesson

Make useful friends...and then use* them

* Well, actually...work 'em like galley slaves...

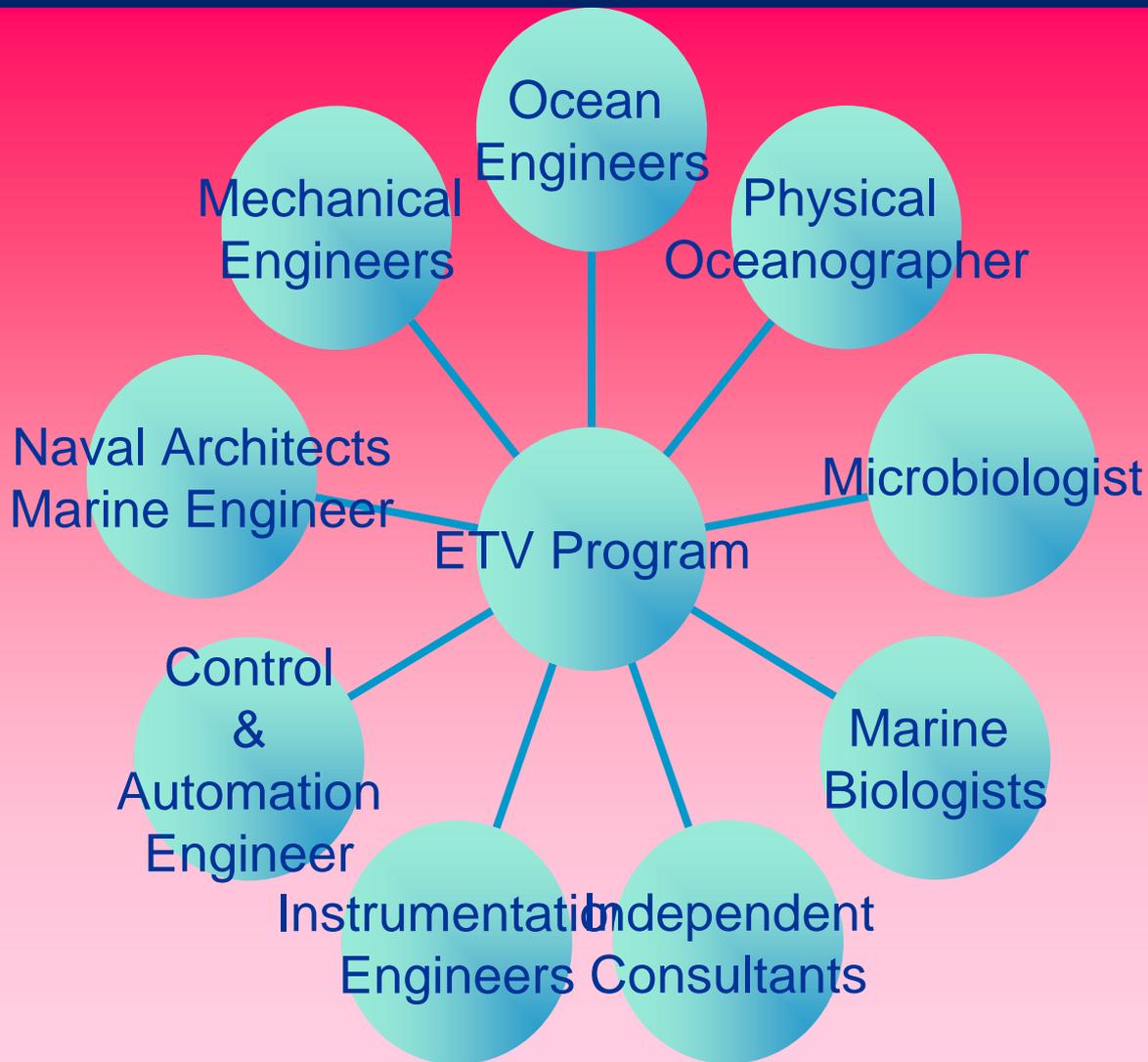
ETV: “The Usual Suspects” A key cadre of technical experts willing to work week ends for little more than food, coffee, and the chance to enjoy the adventure and romance of travel...on federal per diem....

USCG-EPA Partnership

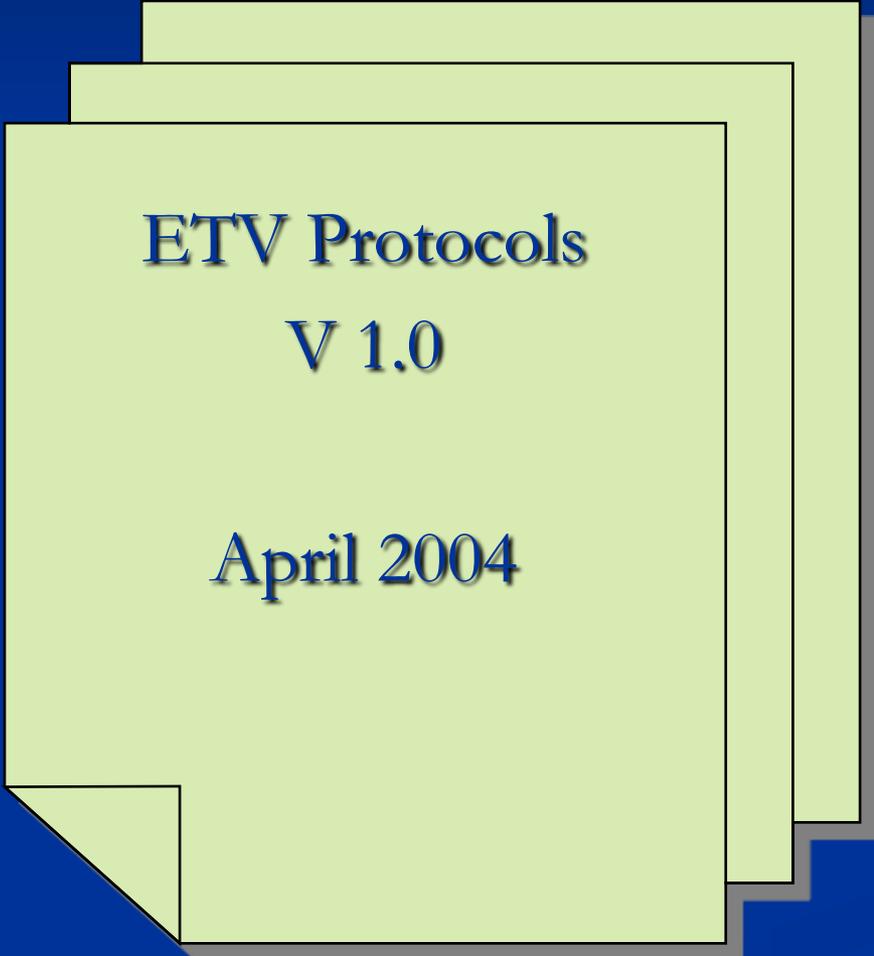
Testing Ballast Water Treatment Systems

- Environmental Technology Verification Program (ETV)
 - USCG-EPA MOU 2002
 - Develop Standardized Test Protocols
 - Transparent procedures
 - Rigorous tests
 - Credible results

ETV Tech Panel



Draft Testing Protocols



ETV Protocols

V 1.0

April 2004

- ❑ ETV Technical Panel & Battelle produced draft protocols in April 2004

- ❑ BPJ

- ❑ Fairly high level guidance

- ❑ Not validated

Lesson

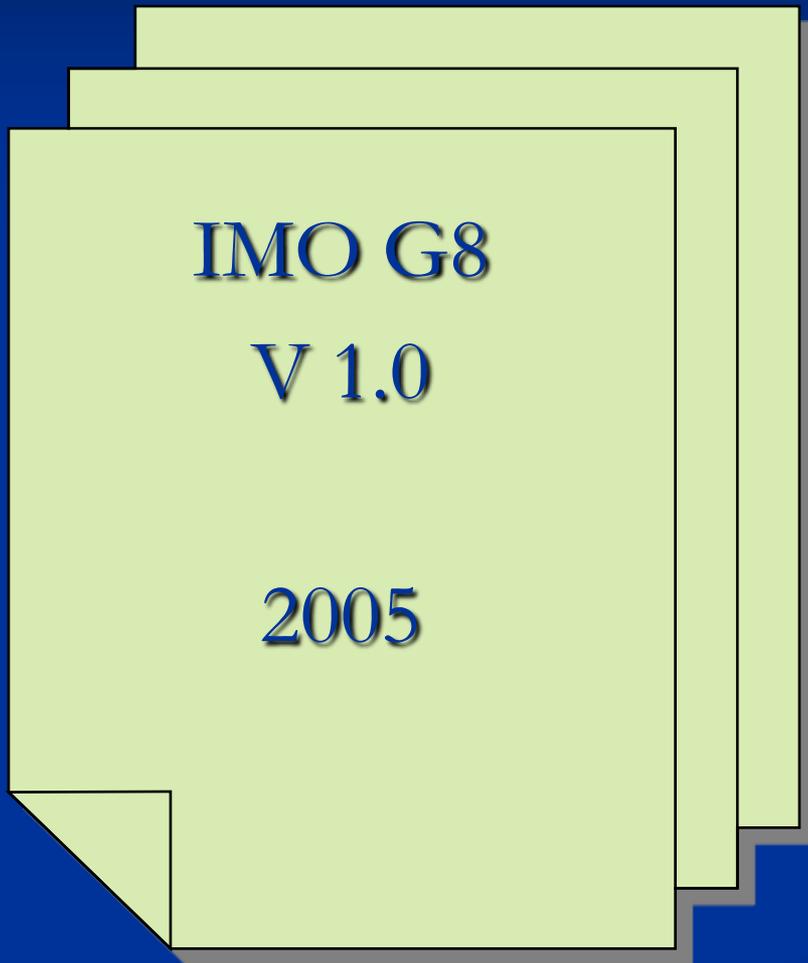
Trust, but Validate

Or

Show me the Data...

(...and the methods, the statistical models, the assumptions, the QA/QC procedures, etc)

A side note on the importance of validation



IMO Guidelines for Approval of Ballast Water Management Systems (G8)

Draft ETV Protocol used as a model

Consensus document

Science & Engineering

International politics

Short time-line

Unvalidated after adoption

Problems with rec's

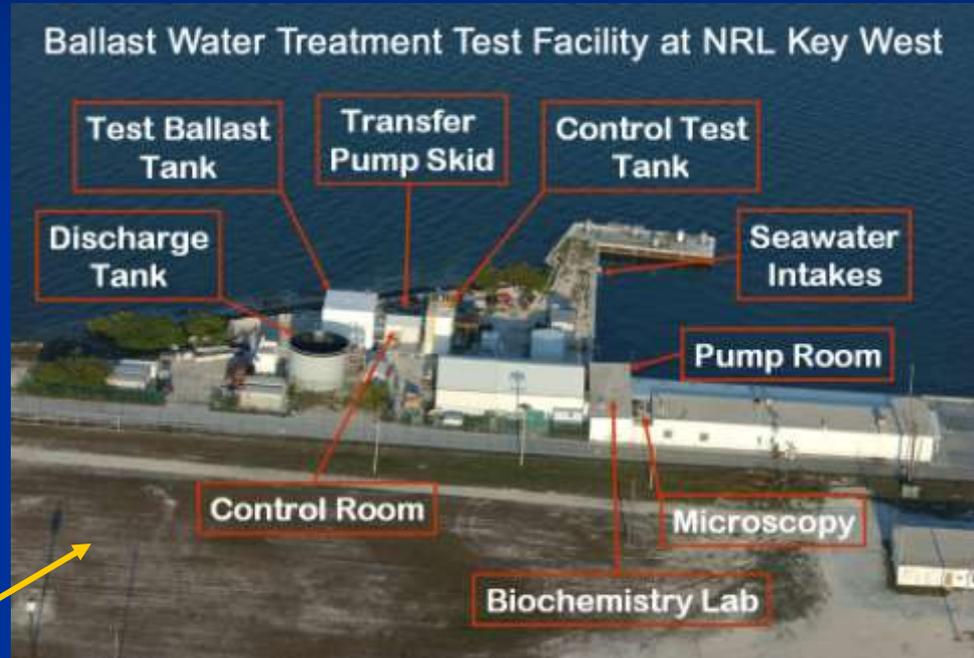
Ad hoc adjustments

Great Uncertainty

Validation

- **USCG Broad Area Announcement**
 - Interest/ability/capacity?
- **USCG and NRL Interagency Agreement**
 - **NRL**
 - Long history of ballast tank/system work
 - Significant physical infrastructure
 - Experienced in T&E of shipboard systems
- **Task: Validate ETV Protocol**
 - Independent review of document
 - Model test pad
 - Pilot test

Pilot BW Treatment Test Facility



Center for Corrosion Science & Engineering
Naval Research Laboratory
Key West, FL



Test Facility Components

Pumps

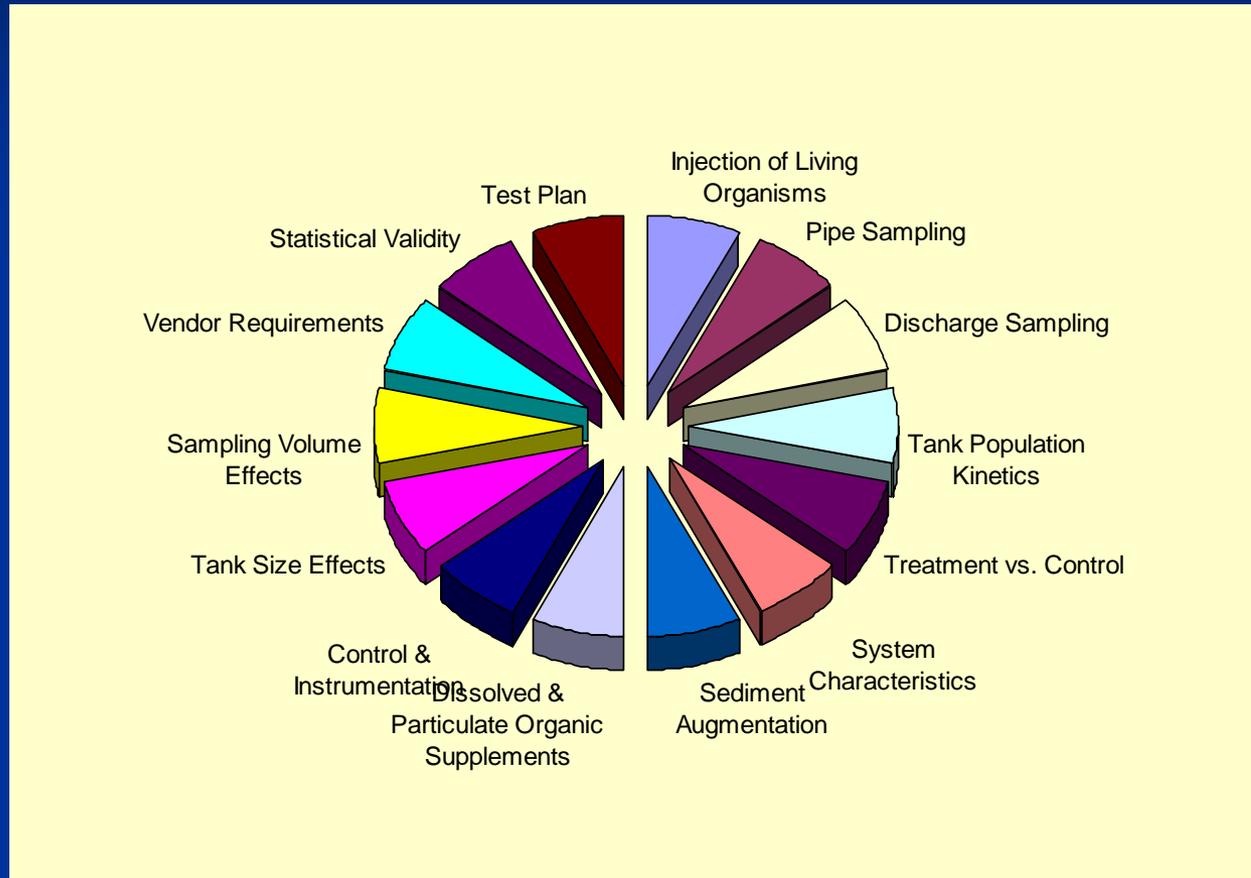


Tanks



Test Pad

Validation of protocols requires solving many challenging problems



Fundamental questions and challenges regarding “HOW-TO” perform testing

Process Control

- **Control and automation essential**
 - Consistency, reliability and economy
 - Scientifically defensible
- **Approach: industrial process control system**
 - Simultaneous operation and feedback control
 - valves, pumps and sensors
 - Data acquisition and archiving
 - Automated data analysis and reduction
 - Alarm conditions for operation outside of specifications
 - Facility
 - BWT manufacturer
- **High degree of control**
 - Guaranteed operating conditions
 - Verifiable record
 - Reduced human error
 - Reduced induced-organism mortality at sampling locations.



Instrumentation

- Over 100 instrumented sensors.
 - Flow rate
 - Pressure & Differential Pressure
 - Temperature
 - Dissolved Oxygen
 - Turbidity (NTU)
 - pH
 - Particle Counts & Size Distribution
- 96 valves
 - Flow rate control
 - Isolation & Flow distribution
 - Sample acquisition
 - Most pneumatic and electrically actuated
 - Manual valves wired with a magneto-sensor for open/closed information and supervisory monitoring (QA/QC purposes)
- Sample acquisition ports pre-BWT, post-BWT, post-tank
 - Organisms
 - Chlorophyll, POC, DOC, CHNP

Lesson

Don't bust...

Or

Let the electrons work the 14 hour days...

...but keep some smart people around...

...and **VALIDATE**

Automation: Rapid and Consistent Analysis

The expert at the 'scope is neither sustainable nor desirable



Counting and Classifying 300 Zooplankton Organisms As Dead or Alive Takes (Poke Method) a Human Operator at Least 3.5 Hours.

Very Difficult to Maintain Observational Consistency

Sample Degradation within 6 hours

Automation results:

- Greatly reduced analysis time

- Image and Video Archive

- Cost Over Time is Less - Fewer Technicians



Automation of Sample Analysis

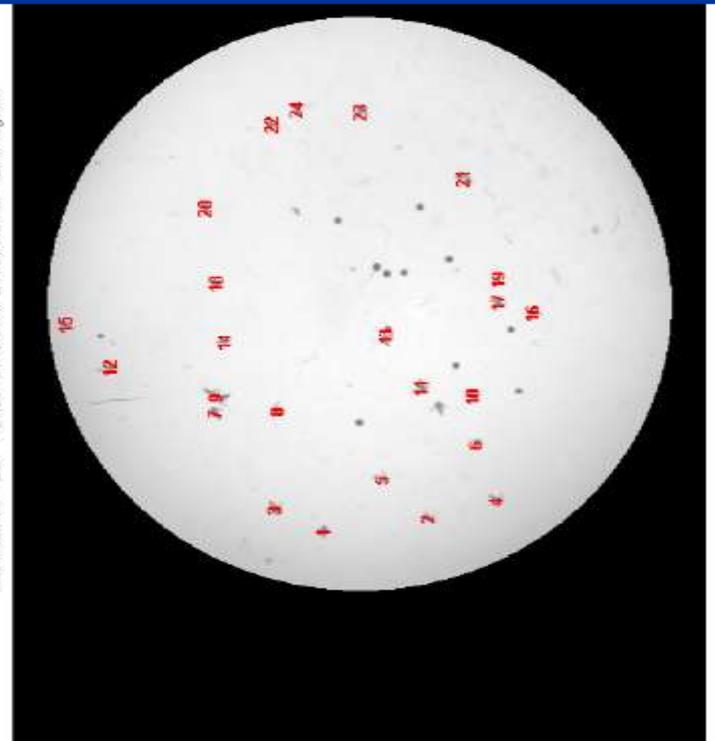
- FlowCAM by Fluid Imaging Technologies Inc.*

- 1 um to 3 mm optical flow cytometer



- In-house Image Analysis
- Larger plankton

Total Artemia = 25. Number of Potential Dead Artemia = 24. Image #1



*Not an endorsement!

Automated Sample Analysis

Initial Results

- Data Archive
 - Particularly image files
- Reduced time
- Increased consistency
- Reduced cost (eventually...)

Consistency and Comparability

- Harmonization is critical among test organizations/facilities
 - Domestic
 - NRL Key West FL
 - GSI Superior WI
 - MERC Baltimore MD
 - PNNL Sequim WA
 - International
 - NIVA Norway
 - NIOZ Netherlands
 - Korea?
 - Japan?
 - South Africa?

Lesson

Don't color outside the lines

Or

Standardization, comparability, and consistency are
critical

Comparability and Consistency Paramount

- Test rigor and QA/QC need to be comparable across tests
 - Within sites
 - Across sites
- Significant variability will hurt
 - Buyers need to know system will perform as needed
 - Certificate alone not enough
 - Approved systems may be required (IMO, U.S.?)*
 - Discharge standard may also apply (IMO, CA, U.S.?)*
 - Regulatory agencies need to have confidence

* Based on pending legislation

Achieving Consistency and Comparability

■ Standard procedures

- Validation

■ Intersite “calibration”

- Analytic methods
 - Spiked blind samples
- Site comparisons
 - Parallel tests

■ Transparency

- Public reports
 - Results
 - Methods

■ Standard Test Organisms

■ Pros

- Common biological link between tests
- Eventually – simplification of analyses??

■ Cons

- Added complexity
 - Culturing, injection, stock consistency
- NIS concerns

Things to Consider

- **Process control and automated analysis are paramount.**
 - Production time scales
 - Large quantities
 - High statistical confidence and rigor
 - High quality assurance
- **Surrogate identification & optimization work required.**
 - Comparability among tests...
 - Significant drawbacks
- **Multiple test sites are likely necessary for reliable and consistent testing in the future.**
 - Test facility designs and procedures require validation
 - Need to ensure a satisfactory level of inter-site comparability





<http://www.uscg.mil/hq/g-m/mso/estandards.htm>